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MODIFICATION TO
STATEMENT OF BASIS
RULE AUTHORIZATION OF INJECTION
AS FINAL REMEDY FOR SITE REMEDIATION
CDOT Region 6 Headquarters Site
2000 South Holly
Denver, CO
EPA #CO5000-04976
February 6, 2002

Background:

In November 1999, Harding ESE, on behalf of CDOT, requested a Rule Authorization to conduct a pilot-scale test to assess whether an active aerobic biodegradation process can be effectively implemented in a complex hydrogeologic setting to remove methylene chloride from groundwater in the Dry Well area of the CDOT Region 6 Headquarters Site at 2000 South Holly Street in Denver. **Figure** G-4 shows the general site plan of the area. A secondary purpose was to assess the potential of the pilot-scale test to stimulate co-metabolic degradation of more highly chlorinated compounds present in groundwater such as PCE, TCE, 1,1 DCE. In a letter dated December 13, 1999, CDOT was issued a Rule Authorization to conduct the pilot test injection activities. The pilot-test system operation began on January 31, 2000, and the pilot test continued through July 21, 2000. Harding ESE submitted a report of the pilot-scale monitoring results on September 20, 2000.

On July 22, 2000, Harding ESE, on behalf of CDOT, requested a 6-month extension of the Rule Authorization in order to continue injection activities and maintain the steady-state permeation of nutrients throughout the plume to maintain the level of microbial activity that had been developed during the pilot test. The 6-month extension of injection activity provided for continuation of injection and monitoring activity through January 31, 2001, until the final remediation strategy could be implemented. In a Rule Authorization Modification letter dated July 28, 2000, the time frame for the pilot test was extended to January 31, 2001.

In a letter dated December 18, 2000, Harding ESE, on behalf of CDOT, requested a second extension to the injection activities to allow for the development of the *Draft Final Corrective Measures Work Plan* and public comment period on the expansion of the pilot test injection activity as the proposed presumptive remedy. The *Draft Final Corrective Measure Work Plan* dated December 22, 2000, was submitted to CDPHE. In a Rule Authorization Modification letter dated Jan 5, 2001, the time frame for the pilot test was extended to July 31, 2001. Injection activity stopped on May 31, 2001.

In a letter dated April 17, 2001, CDPHE provided CDOT with comments on changes to the *Draft Final Corrective Measure Work Plan* to be incorporated into a *Final Corrective Measure Work Plan.* On May 1, 2001, CDPHE and CDOT met to discuss CDOT's proposed responses to the April 17, 2001 comments. In a letter dated May 18, 2001, CDOT documented the responses to CDPHE's April 17, 2001 comments. In a letter dated June 8, 2001, CDPHE issued a letter approving CDOT's responses as documented in the May 18, 2001 letter. The *Final Corrective Measure Work Plan* was submitted to CDPHE on July 12, 2001. After Public Comments were received, a subsequently revised *Final Corrective Measure Work Plan* was approved by CDPHE in a letter dated December 20, 2001.

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Table 1.1 includes a summary of corrective actions required under the Order on Consent issued by CDPHE. Note that this Statement of Basis and Rule Authorization Modification covers remedial activity at the Dry Well location. Ground water in the areas near monitoring wells CMW-6 and CMW-7 will addressed pending the assessment of results from the RCRA Facilities Investigation being conducted by the Brown Group at the former Redfield property as specified in CDPHE's April 17, 2001 letter. In the interim, CDOT will continue semiannual ground water sampling in the vicinity of these two wells.

CDOT contractors have performed investigations to evaluate geology, ground water flow conditions, and nature and extent of contamination at the Region 6 Headquarters site. These investigations are documented in an Environmental Site Assessment report and a Site-Wide Soil and Ground Water Investigation report. Results of sampling conducted during site investigation indicate that the primary area of ground water contamination at the site originates from the former Dry Well that was used for disposal methylene chloride. The contaminant plume is localized in the area east of the Site Materials Lab building and west of the Redfield building. In this area, ground water is contaminated with methylene chloride, PCE, TCE, and 1,1 DCE.

Pathways of contamination migration: VOC's appear to have migrated vertically from the bottom of the former Dry Well (approximately 11 ft bgs), through the unsaturated zone, and to the water table at approximately 20 ft bgs (based on pre-pilot test water levels). This is supported by data that show the highest detections of methylene chloride occurred in Monitoring Well C-MS20S; an upper zone well installed at the location of the former Dry Well. Data collected during the Interim Measures investigation performed by Harding ESE (then HLA), indicate that the greatest mass of contaminants (primarily methylene chloride) entering the bedrock ground water system in the Dry Well area have migrated down gradient preferentially through the weathered sandstone unit~~s~~ of the upper and lower zones. However, the migration pathways through the sandstones is tortuous and is dependent on cementation, percentage of fine-grained matrix, and other characteristics of these sandstones. Where these sandstones pinch out, flow rates are expected to significantly decrease in the adjacent bedrock claystones. The low permeability of the 2 to 8 foot thick claystone separating the upper and lower sandstones, forces the ground water flow and contaminant migration to be predominantly horizontal. Hydraulic characteristics and differences in ground water chemistry between the upper and lower semi-confined sandstone also indicate the primary pathway for contaminant migration into the lower aquifer was not vertical migration through the overlying claystone aquitard, but through localized areas where the overlying claystone is absent and the two sandstone units converge or through vertical or high-angle fractures in the claystone, and possibly from vertical flow through the former well bore at C-MW11.

There is also arsenic contamination in the soil at this site. In a letter dated Sept 27, 2000, CDPHE has directed CDOT to implement institutional controls for the high arsenic levels within the soil and include a system to manage the institutional controls in the final remedy document for the site. These institutional controls will included site access restrictions, maintenance of the existing asphalt cover, appropriate signage and future land use restrictions and deed restrictions.

The *Final Corrective Measures Work Plan* prepared by Harding ESE, and approved by CDPHE on December 20, 2001, CDOT focuses on using in-situ biodegradation under aerobic conditions as the presumptive final remedy for active remediation of the contaminated ground water plume in the Dry Well area. The preferred alternative will implement a full-scale in-situ bioremedation system, expanding the injection system previously rule authorized as a pilot test.

Corrective Action Objectives related to injection activities:
The purpose of the corrective action injection activities for the site is to control or reduce contaminant concentrations to a level that poses little adverse short and long-term effects to human health and the environmental. The general objectives developed for corrective action at the site include the following:

1. Prevent further off-site migration of contaminated ground water that contains constituents at concentrations exceeding the State of Colorado ground water standards and MCLs.
2. Reduces dissolved-phase contaminant concentrations associated with the dry well release to State ground water standards and MCLs.

Description and Evaluation of the Presumptive Remedy for the Dry Well area: The presumptive remedy for ground water in the Dry Well area will expand on the in situ aerobic biodegradation technology successfully demonstrated during the pilot scale test conducted at that location.

The processes of aerobic biodegradation: Organic compounds generally represent reduced forms of carbon and are therefore susceptible to oxidation. Halogenated compounds are relatively oxidized by the presence of halogen substituents with the more substitutes; the more oxidized the compound and the more susceptible to reduction. Methylene chloride is a low to moderately halogenated compound, thus it is susceptible to oxidation. In a highly aerobic oxidizing environment, such as that created during the CDOT pilot-scale studies, the oxidation mechanisms for methylene chloride oxidation are related to the oxygenase family of enzymes. This family of enzymes oxidizes halogenated compounds by four general mechanisms: 1) incorporation of oxygen in the carbon-hydrogen bond, 2) oxidation of the halogen substituent, 3) oxidation of the carbon-carbon double bond via epoxidation, and 4) biohalogenation of the carbon-carbon double bond.

In all of these cases the resulting end products of the oxidation process are a halogenated intermediate (which subsequently oxidized to carbon dioxide), hydrogen ions, and free electrons. This is unlike reductive dehalogenation, which involves the stepwise removal of substituted halogens in the metabolic process and an accumulation of chloride and other more potentially toxic chlorinated degradation products. Conversely, an aerobic oxidative metabolic process does not necessarily result in the accumulation of measurable breakdown products such as chlorides or chlorinated degradation products.

The presumptive remedy will include the installation of injection wells and monitoring wells in the upper and lower zones, installation of a nutrient and oxygen feed system and injection pumps, operation of the injection system, and ground water monitoring. The system will be capable of continuously injecting nutrients, oxygen, and methane into a maximum of 20 wells simultaneously to establish and maintain aerobic biodegradation of the contaminant plume. The ground water remediation goals are listed in **Table** 3.1.

Twenty-two new wells will be installed during the implementation of the presumptive remedy. **Table** 4.1 summarizes the estimated depths and well completion information for each of the new monitoring well and injection wells to be installed. In response to concerns raised by CAPCO management, the current tenants on the adjacent Brown Group property about the number of wells to be installed in the high-volume traffic area on the west side of their building, as many as 14 wells (seven upper zone and seven lower zone) will be installed a dual completions. The dual-well completions will allow the number of well vaults to be minimized while will providing the necessary coverage of the plume area and system flexibility requested by both CDPHE and the Brown Group. **Figure** C-3 is the schematic drawing for single completion injection and monitoring wells; **figure** C-4 shows the schematic for dual completion injection and monitoring wells. The initial injection system will use 17 of the injection wells. There will be 6 monitoring wells that are convertible to injection well. This design will provide CDOT the added flexibility to vary the configuration of the system in response to changes in the contaminant plume dynamics by providing the ability to take injection wells off-line in some areas and place other will on-line as remediation progresses.

<u>Upper zone wells</u>: Within the upper zone sand unit in the dry well area, 15 new wells will be installed as part of the presumptive remedy implementation. Nine of these wells will be injection wells. There are 2 existing injection wells* making a total of 11 injection points within the upper zone. Eight of the new upper zone wells will be single completion wells. A total of 16 upper zone wells will be monitored during the operation of the in situ biodegradation system. To provide flexibility in the operation of the injection system, 3 upper zone monitoring wells (C-MW21S, C-MW34A, and C-OBS1A) will be modified or completed so that the wells can be used as injection wells in the future, if necessary. The locations of injection wells and monitoring wells completed within the upper zone are shown in the figure labeled **Figure 3.1**.

* C-MW20S
C-MW23

<u>Lower zone wells</u>: Seven new wells will also be completed in the lower zone sand unit

during the implementation of the presumptive remedy. Within the lower zone in the dry well area, 4 new injection wells well be installed and the 2 existing well will remain active as injection wells for a total of 6 injection wells, located as shown in **Figure 3.2**. Three new monitoring wells will also be installed to monitor the performance of the presumptive remedy. In total, 14 lower zone wells will be monitored during the operation of the in situ biodegradation system. To provide flexibility in the operation of the injection system, 3 lower zone monitoring wells (C-MW21D, C-MW31B, and C-MW35B) will be modified or completed so that the wells can be converted to injection wells in the future, if necessary.

An injection delivery system will be constructed in the dry well area to facilitate the enhancement of in situ aerobic biodegradation through the addition of oxygen, nutrients (including potassium phosphate and ammonium nitrate), and methane to the subsurface. A potassium bromide tracer will be injected during the first 10 days of system operation to provide a means of assessing the hydraulic ~~hydraulic~~ coverage of the injection system.

Description of the Aerobic Biodegradation Remediation System: In-situ aerobic biodegradation is a technology in which indigenous bacteria degrade organic constituents found in soil and ground water. Implementing the aerobic biodegradation technology for treating VOCs of interest in the Dry Well area involves mixing and supplying the necessary oxygen, nutrients, organic substrates, and/or electron acceptors through injection into the proposed injection well network. The injected mixture will stimulate the growth of indigenous bacteria that successfully degraded the VOCs of interest during the pilot scale test of this technology. This process accelerates the rate of biotransformation and biodegradation of the VOCs to innocuous by-products (i.e. carbon dioxide, chloride ion, and biomass).

The injectate will contain an oxygen-releasing compound (e.g. hydrogen peroxide), nutrients, and methane. The then concentrations of hydrogen peroxide will range from 100 mg/l at system startup to as high as 800 mg/l during full system operation. The hydrogen peroxide used will be at a 35% concentration. The nutrients will consist of ammonium nitrate in a concentration of approximately 50mg/l and potassium phosphate in a concentration of approximately 5 mg/l. Methane gas will be added to the injection stream near the end of the system startup period. A rate of approximately 0.39 cubic inches of methane per gallon of injected water will be controlled with a pressure regulator and valves. This rate results in a methane concentration of 1.14 mg/l at a pressure of 14.7 psi and 60 degrees Fahrenheit.

Treatment Startup Approach: The treatment system will be implemented in a phased approach in both the upper and lower zone as follows:

First 2 weeks: Process water with inorganic nutrients including ammonium nitrate at 50 mg/l and potassium phosphate at 5 mg/l will be injected into the injection wells. Potassium bromide will be added to this mixture and injected at a concentration of 100 mg/l.

Weeks 2 through 4: Oxygen will be introduced into the injection wells via the addition of hydrogen peroxide (at an initial concentration of 100 mg/l) to the process water supplemented with inorganic nutrients. During this period, oxygen and phosphate levels will be monitored. The concentrations of the hydrogen peroxide will be slowly increased from the initial concentration of 100 mg/l to a maximum concentration of 800 mg/l.

After 4 weeks: Methane (at 1.14 mg/l) will be added to the oxygenated process with inorganic nutrients. Injection flow rates will also be increased slowly from an initial rate of 0.05 gpm to 0.10 gpm, or until the injection remains below 30 psi. This phased approach will assure that the methane front will not ravel further that the oxygen and nutrient front, hence optimizing bacterial populations prior to the injection of methane and, therefore, optimizing methane utilization in the treatment area. These proposed time frames are subject to the amendment travel time, therefore, the durations are estimates that may vary on the basis of actual field conditions.

Monitoring Strategy: A ground water monitoring program will be implemented as part of the presumptive remedy to track the degradation of VOCs in the ground water in the Dry Well area. In general, ground water monitoring will include collection of water level measurements, collection of field parameters and ground water samples from a total of 30 upper and lower zone monitoring wells in the Dry Well area (Figures 3.1 and 3.2), and analysis of the samples for biological parameters and VOCs.

<u>Stage 1 - Baseline Monitoring</u>: This stage will be conducted subsequent to the pilot-scale system shutdown and prior to full scale treatment system startup and will consist of a baseline sampling event to document and establish initial subsurface biological and hydrologic conditions in both the upper and lower zones of the Dry Well Plume Area. Ground water sampling and analyses for chemical and biological parameters, and VOCs will be conducted in accordance with the schedule presented in **Table** A3. Ground water samples will be analyzed for the following field parameters, chemical and biological parameters, and VOCs:

1. pH, conductivity, temperature, oxidation/reduction potential (ORP), dissolved oxygen (DO), phosphate, and carbon dioxide;
2. methane, nitrate, chemical oxygen demand (COD), and total organic carbon (TOC); and
3. VOCs.

Ground water samples will be collected from the monitoring well network presented in **Table** A3. After the analytical data are reviewed, the baseline of chemical and VOC concentrations for the individual injection and monitoring wells can be established. These data will provide the basis for comparison of operational monitoring data.

<u>Stage 2 – Operational Monitoring</u>: Monitoring activities will be initiated subsequent to the startup of the treatment system and will continue through the life of the treatment

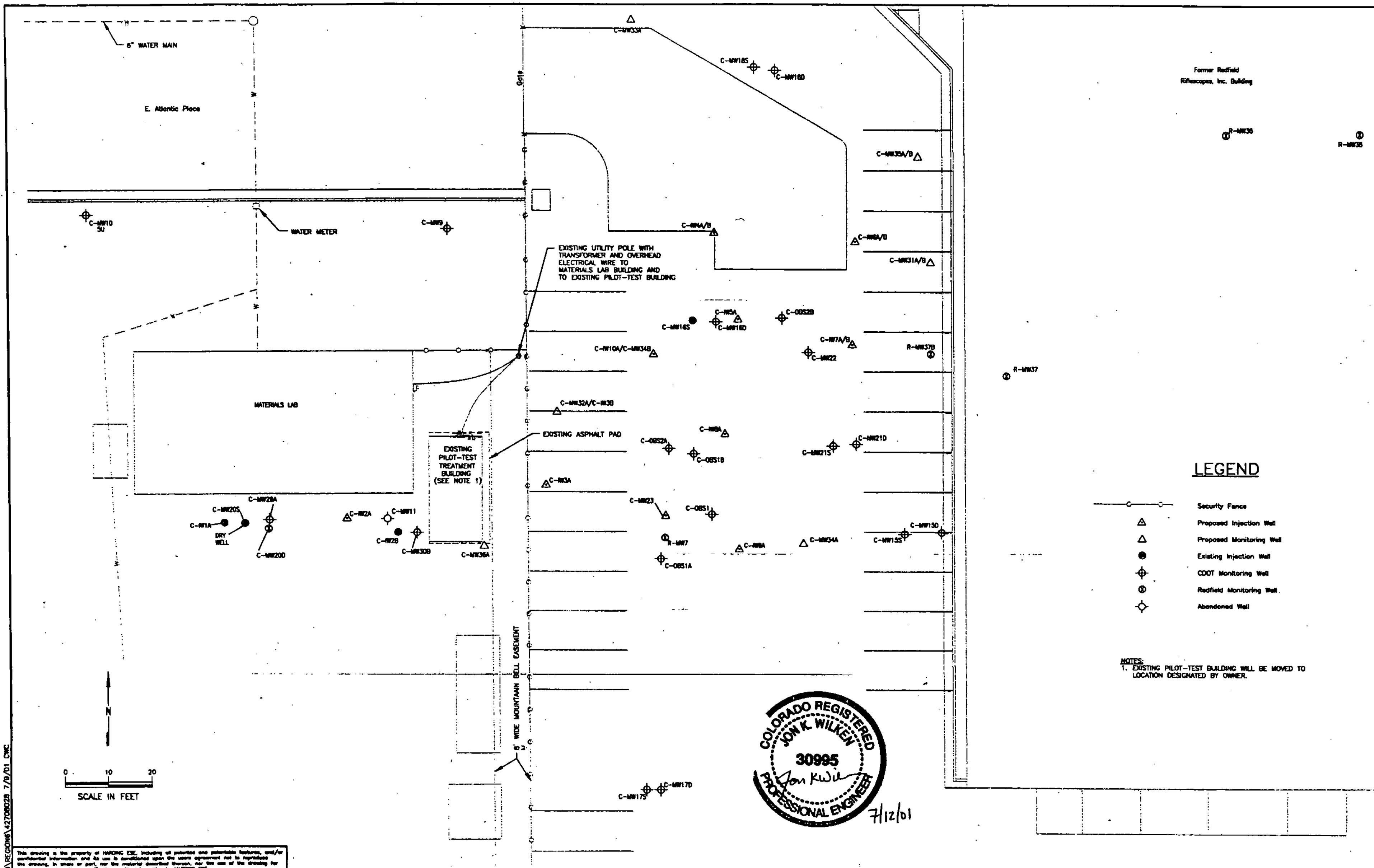
system operations. As outlined in **Table** A3, the frequency of Stage 2 ground water monitoring events will decrease over time. Results from the more frequent initial Stage 2 monitoring round will be used to evaluate how effective the treatment system injection well array is affecting biological activity and to monitor when chemical and biological indicators have achieved a sufficient level to sustain prolonged, uniform biodegradation in the Dry Well area. After the first 6 months of treatment system operation, scheduled monitoring activities will be used to monitor how the added nutrients and chemicals are affecting the degradation rates in the Dry Well area for the duration of the operational period. The schedule for conducting the State 2 monitoring activities is presented in **Table** A3. After system startup is complete, samples will be collected at 2, 4, and 8 weeks of operation. Samples will then be collected at 3, 6, 9, and 12 months of operation. The frequency of ground water monitoring will be reduced to semi-annual events beginning in the 2nd year of system operation and extending through the end of the 4th year (13 months through 48 months). Beyond the 4th year of operation, ground water monitoring well be schedule on an annual basis.

During the progression of treatment system operation and Stage operation ground water monitoring, a number of scenarios are possible with respect to ground water remediation.

1. Scenario 1 – The monitoring well network and treatment system data indicate that the system is effectively achieving the ground water remediation goals and operating as designed. Therefore, the treatment system operating procedures will not be modified and the system will continue to be operated and monitored following the schedule for Stage 2 monitoring as present in **Table** A3;
2. Scenario 2 – The monitoring well network and treatment system data indicated that remediation is on-track for achieving the ground water remediation goals in a timely manner if slight modifications to the existing treatment system operations are made. Therefore, the treatment system will be modified, as appropriate, and operated and monitored following the schedule for the Stage 2 monitoring as presented in **Table** A3; or
3. Scenario 3 – The monitoring well network and treatment system data indicate that the treatment system is not on-track with the anticipated remediation schedule. Therefore, a contingency plan and a revised monitoring plan may be required. If necessary, a contingency plan a revised monitoring program will be prepared and submitted to CDPHE for review and approval. Further discussion of possible system evaluation and optimization scenarios is included in Appendix A of the *Draft Final Corrective Measures Work Plan.*

<u>Stage 3 - Post-operational monitoring</u>. Stage 3 monitoring activities will commence after the Site-specific ground water remediation goals are met in the Dry Well area. And the treatment system is turned off. The monitoring activities will include measuring water levels and conducting ground water sampling and analyses for VOCs following the procedures described in Appendix A of the *Draft Final Corrective Measures Work Plan.* The post-operational monitoring activities will be conducted quarterly for 1 year. The monitoring well network, analytical program, frequency, and schedule for Stage 3 monitoring are presented in Table A3. The State 3 monitoring activities will be used to

assess whether the site-specific ground water remediation goals are maintained and the remedial action is complete. If ground water remediation goals set forth in **Table** 3.1 are not maintained during Post-operational monitoring (i.e. rebound in VOC concentrations), the treatment system may be pulsed (i.e. switched on and off) to reduce the rebound concentrations to below the site-specific ground water remediation goals.



P:\40000\42708\CAD\REGION6\42708028 7/9/01 CWC

NO.	DATE	REVISIONS	BY	CHK
1	07/1	FINAL	JKW	KSC

DRAWN: CWC	PROJECT NO: 42708,24.1
ENGINEER: JKW	SCALE: AS SHOWN
CHECKED: KSC	APPROVED: KLD
DATE: 7/12/01	DATE: 7/12/01

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CDOT REGION 6 HEADQUARTERS
BIODEGRADATION
INJECTION SYSTEM
DENVER, COLORADO

GENERAL

GENERAL SITE PLAN

DRAWING NO: G-4

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Table 1.1: Summary of Corrective Action Requirements for the Compliance Order on Consent CDOT Region 6 Headquarters Facility

Compliance Order on Consent Reference Paragraph	Report	Submittal Date	CDPHE Action Date	Comments
Paragraph 16	Final Site Investigation Report (Current Conditions Report)	June 30, 1998	September 29, 1998	The CDPHE approval letter indicated that sufficient information was presented in the *Final Site Investigation Report* to move forward with the preparation of the Soil and Groundwater Characterization Plans. The letter noted that comments raised therein could be addressed in the requested work plans. Additional comments were issued by CDPHE on December 9, 1999.
Paragraphs 17 - 18 and 20- 21	Soil and Groundwater Characterization Plan	January 22, 1999	July 27, 1999	Two extensions for the submittal of the Plan were granted to afford CDOT and CDPHE an opportunity to reach agreement on proposed SROs for the Site prior to finalizing the work plan. The CDPHE approval letter included modifications which were incorporated into the implementation of the soil and groundwater characterization at the Site
Paragraphs 19 and 22	Implementation of SGC	August 7, 1999	NA	Implemented with modifications specified in the CDPHE approval letter for the SGCP.
Paragraph 26	Soil and Groundwater Characterization Report	November 24, 1999	April 27, 2000	On March 6, 2000, CDPHE issued comments on the Report requesting further information relative to soil and groundwater conditions at the Site and the preparation of a supplemental work plan for additional investigation. CDOT provided responses to CDPHE's initial comments on March 28, 2000. Upon review of the responses, CDPHE issued a letter on April 27, 2000 with subsequent comments and a request for the preparation of a supplemental work plan for additional soil and groundwater characterization at the Site. On May 10, 2000, CDOT provided additional response to the CDPHE comments from their April 27th letter.

Table 1.1: Summary of Corrective Action Requirements for the Compliance Order on Consent
CDOT Region 6 Headquarters Facility

Compliance Order on Consent Reference Paragraph	Report	Submittal Date	CDPHE Action Date	Comments
Paragraphs 27 and 28	Additional Soil and Groundwater Characterization Plan	May 9, 2000	May 24, 2000	Verbal approval by CDPHE with modifications received on May 16,2000
Paragraph 29	Implementation of Additional SGC	May 16, 2000	NA	Implemented with modifications specified in the CDPHE approval letter for the Additional SGCP
Paragraph 30	Soil and Groundwater Characterization Report Addendum	July 13, 2000	September 27, 2000	The approval letter directed CDOT to prepare a Corrective Measures Work Plan to address groundwater contamination associated with the Dry Well area and to incorporate institutional controls at the Site to address sporadic detections of metals in soil that exceed unrestricted land use values.
Paragraph 31	Draft Final Corrective Measures Work Plan	December 22, 2000	April 18, 2001	CDPHE issued a disapproval letter with comments. At a May 1, 2001 meeting with CDPHE, CDOT proposed to submit a revised CMWP with a presumptive remedy for the Site. CDOT then provided responses to CDPHE's comments on May 18, 2001. Upon review of the responses, CDPHE issued an approval with clarifications of the CDOT response to comments on June 8, 2001. The June 8, 2001 letter requested a revised CMWP to be submitted within 30 days.

Table 1.1: Summary of Corrective Action Requirements for the Compliance Order on Consent
CDOT Region 6 Headquarters Facility

Compliance Order on Consent Reference Paragraph	Report	Submittal Date	CDPHE Action Date	Comments
Paragraph 31 (continued)	Final Corrective Measures Work Plan	July 12, 2001 August 28, 2001 December 18, 2001 January 24, 2002	August 16, 2001 December 4, 2001	CDPHE issued an acceptance letter with modifications requesting replacement pages to be submitted within 14 days. CDOT submitted replacement pages on August 28, 2001. Following the subsequent 30-day public comment period, CDPHE issued a response to public comments to CDOT in a letter dated December 4, 2001 requesting a response within 30 days. CDOT submitted a response on December 18, 2001 accepting the final CDPHE conditions and included replacement Figures 3.1 and 3.2. On January 11, 2002, CDOT and CDPHE met to resolve the incorporation of a bromide tracer study into the CMWP. The replacement pages incorporating the bromide tracer study were issued by CDOT on January 24, 2002.
Paragraph 35	Monthly Status Reports	15th day of each month	On going	CDOT has submitted the monthly reports as required by the Compliance Order
Paragraph 54 – Additional Requirements	Interim Measures: Work Plan – Phase I	November 2, 1998	November 27, 1998	CDOT requested voluntary interim measures to expedite the soil and groundwater investigation of the Dry Well area. CDPHE approved the proposed activities with conditions that subsequent phases would be successively implemented as deemed necessary by assessment of data by CDPHE and CDOT
	Phase I Implementation	December 1998 to January 1999	NA	
	Preliminary Letter Report	March 9, 1999	NA	Presentation of preliminary results from Phase I pending completion of additional IM characterization of the Dry Well area.
	Phase II Implementation	March 1999	NA	

Table 1.1: Summary of Corrective Action Requirements for the Compliance Order on Consent
CDOT Region 6 Headquarters Facility

Compliance Order on Consent Reference Paragraph	Report	Submittal Date	CDPHE Action Date	Comments
Paragraph 54 (continued)	Phase III Implementation	May – July 1999	NA	
	Final Interim Measures Report	October 22, 1999	February 1, 2000	CDPHE reviewed the report and subsequently issued comments in a letter. Additional information was provided to CDPHE in response to their comments with a letter dated February 29, 2000.
	Biodegradation Pilot-scale Test:	October 6, 1999	NA	As a conclusion to the interim measures for the Dry Well Area, CDOT proposed to implement a pilot-scale test for assessing the practicality and effectiveness of enhanced aerobic biodegradation for the reduction of VOCs in groundwater.
	Biodegradation Pilot-scale Injection Testing Work Plan	November 16, 1999	NA	
	Biodegradation Pilot-scale Test Implementation	January 31, 2000 – May 4, 2001	NA	
	Biodegradation Pilot-scale Test Assessment Report	September 20, 2000	NA	
	Public Comment Period and Public Meeting	September 18 – October 18, 2001	NA	CDPHE directed that a public comment period for the Final CMWP be held. As part of the public comment period, CDOT held a public information meeting on September 26, 2001 to discuss the presumptive remedy with neighboring citizens.

Table 1.1: Summary of Corrective Action Requirements for the Compliance Order on Consent
CDOT Region 6 Headquarters Facility

CDOT	Colorado Department of Transportation
CDPHE	Colorado Department of Public Health and Environment
CMWP	Corrective Measures Work Plan
NA	Not applicable
SGCP	Soil and Groundwater Characterization Plan
SRO	Soil Remediation Objective
VOC	Volatile organic compound

Table 3.1: Groundwater Remediation Goals
CDOT Region 6 Headquarters Facility

Analyte Name	National Primary Drinking Water Standard (MCL)*	State Groundwater Quality Standard#	Site-specific Groundwater Remediation Goal
Volatile Organic Compounds (µg/l)			
1,1,1-Trichloroethane	200	200	200
1,1,2-Trichloroethane	5	3	3
1,1-Dichloroethane	NA	NA	NA
1,1-Dichloroethene	7	7	7
1,2-Dichloroethane	5	0.4	0.4
cis-1,2-Dichloroethene	70	70	70
trans-1,2-Dichloroethene	100	100	100
Carbon tetrachloride	5	0.3	0.3
Chloroethane	NA	NA	NA
Chloroform	80	6	6
Methylene chloride	5	5	5
Tetrachloroethene	5	5	5
Trichloroethene	5	5	5
Vinyl chloride	2	2	2

Concentrations listed above are in micrograms per liter.

MCL Maximum contaminant level
NA Not available, no regulatory standard established

* The National Primary Drinking Water Standards are identified from the "Drinking Water Regulations and Health Advisories" by the Office of Water – U. S. Environmental Protection Agency, EPA 810-F-94-001, December 1999.

The State Groundwater Quality Standards are identified in the Colorado Department of Public Health – Water Quality Control Commission – "Regulation No. 41 -Basic Standards for Groundwater" (41.5B).

Table 4.1: Construction Details for New Monitoring and Injection Wells
Presumptive Remedy
CDOT Region 6 Headquarters Facility

Well ID	Well Type	Well Depth (feet)	Well Diameter (inches)	Estimated Depth to Bedrock (feet bgs)	Cement-Bentonite Grout Thickness (feet)	Sand Pack Thickness (feet)	Bentonite Seal Thickness (feet)	Screen Interval (feet bgs)	Screen Length (feet)	Well Screen Material	Well Casing Material
C-IW2A	Injection	32	2	17	21	7	4	27-32	5	SS	SS/PVC
C-IW3A	Injection	32	2	14	22	7	3	27-32	5	SS	SS/PVC
C-MW32A	Monitoring	30	2	14	14	12	4	20-30	10	SS	
C-IW3B	Injection	56	2	14	3	21	2	36-56	20	SS	SS/PVC
C-IW4A	Injection	30	2	14	15	12	3	20-30	10	SS	SS/PVC
C-IW4B	Injection	55	2	14	2	21	2	35-55	20	SS	SS/PVC
C-IW5A	Injection	30	2	14	15	12	3	20-30	10	SS	SS/PVC
C-IW6A	Injection	30	2	16	19	7	4	25-30	5	SS	SS/PVC
C-IW6B	Injection	58	2	16	4	21	3	38-58	20	SS	SS/PVC
C-IW7A	Injection	30	2	15	14	12	4	20-30	10	SS	SS/PVC
C-IW7B	Injection	56	2	15	3	21	2	36-56	20	SS	SS/PVC
C-IW8A	Injection	30.5	2	12	19.5	7	4	25.5-30.5	5	SS	SS/PVC
C-IW9A	Injection	32	2	15	16	12	4	22-32	10	SS	SS/PVC
C-IW10A	Injection	30	2	14	14	12	4	20-30	10	SS	SS/PVC
C-MW34B	Monitoring	56	2	14	3	21	2	36-56	20	SS	SS/PVC
C-MW31A	Monitoring	30	2	15	19	7	4	25-30	5	PVC	PVC
C-MW31B	Monitoring	58	2	15	4	21	3	38-58	20	SS	SS/PVC

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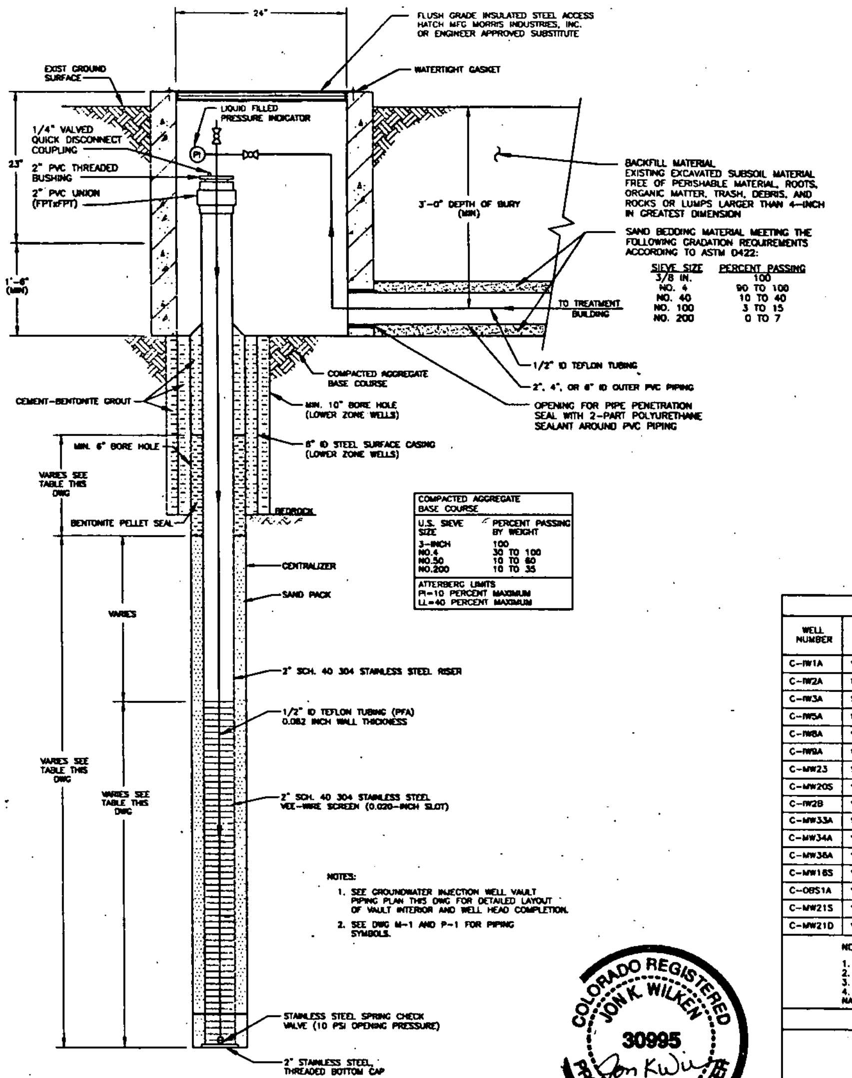
07/12/01 CMWP

Table 4.1: Construction Details for New Monitoring and Injection Wells
Presumptive Remedy
CDOT Region 6 Headquarters Facility

Well ID	Well Type	Well Depth (feet)	Well Diameter (inches)	Estimated Depth to Bedrock (feet bgs)	Cement-Bentonite Grout Thickness (feet)	Sand Pack Thickness (feet)	Bentonite Seal Thickness (feet)	Screen Interval (feet bgs)	Screen Length (feet)	Well Screen Material	Well Casing Material
C-MW33A	Monitoring	29	2	19	18	7	4	24-29	5	PVC	PVC
C-MW34A	Monitoring	31	2	13	15	7	4	26-31	5	SS	SS/PVC
C-MW35A	Monitoring	30	2	15	19	7	4	25-30	5	SS	SS/PVC
C-MW35B	Monitoring	58	2	15	4	21	3	38-58	20	SS	SS/PVC
C-MW36A	Monitoring	31	2	15	20	7	4	26-31	5	PVC	PVC

An 'A' in the Well ID denotes an upper zone well completion
A 'B' in the Well ID denotes an lower zone well completion

amsl	Above mean sea level
bgs	Below ground surface
PVC	Polyvinyl chloride
SS	Stainless steel



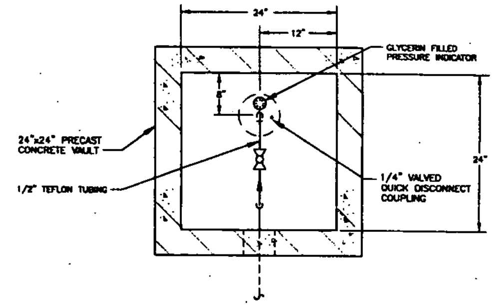
COMPACTED AGGREGATE BASE COURSE	
U.S. SIEVE SIZE	PERCENT PASSING BY WEIGHT
3-INCH	100
NO.4	30 TO 100
NO.50	10 TO 60
NO.200	10 TO 35
ATTERBERG LIMITS	
PI=10 PERCENT MAXIMUM	
LL=40 PERCENT MAXIMUM	

NOTES:

1. SEE GROUNDWATER INJECTION WELL VAULT PIPING PLAN THIS DWG FOR DETAILED LAYOUT OF VAULT INTERIOR AND WELL HEAD COMPLETION.
2. SEE DWG M-1 AND P-1 FOR PIPING SYMBOLS.

INJECTION WELL AND VAULT PIPING SECTION (A / C-2)

NTS



INJECTION WELL VAULT PIPING PLAN

NTS

NOTE: INSULATED ACCESS HATCH AND WELL COMPLETION OMITTED FOR CLARITY (SEE SPECS)

INJECTION/MONITORING WELL AND CONSTRUCTION TABLE

WELL NUMBER	NORTHING	EASTING	GROUND SURFACE ELEVATION[1]	APPROX. WATER ELEVATION[2] (FEET AMSL)	APPROX. DEPTH TO BEDROCK[3] (FEET BGS)	APPROX. DEPTH OF SURFACE CASTING	FEET OF CEMENT-BENTONITE GROUT	FEET OF SAND PACK	FEET OF BENTONITE PELLET SEAL	SCREEN INTERVAL (FEET BGS)	SCREEN LENGTH (IN FEET)	SAND PACK MATERIAL	SCREEN SLOT SIZE (INCHES)	TOTAL DEPTH (FEET BGS)
C-IW1A	1,673,443	3,162,954	5457.3	5439.0	18.5	NA	9	16.5	4	14.45–29.06	14.61	16–30	0.02	29.5
C-IW2A	1,673,444	3,162,981	5457.0	5438.2	17	NA	21	7	4	27–32	5	16–30	0.02	32
C-IW3A	1,673,451	3,163,026	5456.0	5437.0	14	NA	22	7	3	27–32	5	16–30	0.02	32
C-IW5A	1,673,489	3,163,069	5454.5	5435.0	14	NA	15	12	3	20–30	10	16–30	0.02	30
C-IW8A	1,673,437	3,163,066	5454.5	5435.3	12	NA	19.5	7	4	25.5–30.5	5	16–30	0.02	30.5
C-IW9A	1,673,463	3,163,069	5454.5	5435.5	15	NA	16	12	4	22–32	10	16–30	0.02	32
C-MW23	1,673,445	3,163,053	5455.2	5436.0	12.3	NA	22	7.5	3	27.4–32	4.6	10–30	0.02	33
C-MW20S	1,673,443	3,162,958	5457.3	5440.0	17	NA	18.5	12.5	2	22.7–32	9.3	10–30	0.02	37
C-IW2B	1,673,441	3,162,993	5456.6	5439.0	15.5	31.3	28	22.5	4	34.3–54.3	20	16–30	0.02	54.5
C-MW33A	1,673,555	3,163,045	5454.2	5434.8	19	NA	18	7	4	24–29	5	16–30	0.02	29
C-MW34A	1,673,438	3,163,084	5454.5	5435.1	13	NA	15	7	4	26–31	5	16–30	0.02	31
C-MW36A	1,673,438	3,163,012	5456.8	5437.2	15	NA	20	7	4	26–31	5	16–30	0.02	31
C-MW16S	1,673,489	3,163,059	5454.5	5429.8	14	NA	35	18.5	4	41.5–56.5	15	10–30	0.02	61.5
C-OBS1A	1,673,435	3,163,052	5455.3	5437.1	12.3	NA	20	7	3	25.8–30.5	5	10–30	0.02	32
C-MW21S	1,673,460	3,163,090	5454.7	5435.1	13.4	NA	14	12.5	3	20–29.4	10	10–30	0.02	30.5
C-MW21D	1,673,461	3,163,095	5454.6	5436.7	13.4	35	33.5	19	2	42.7–57	15	10–30	0.02	57.9

NOTES:

1. WELLS C-IW1A, C-MW23, C-MW20S, C-IW2B, C-MW16S, C-OBS1A, C-MW21S, AND C-MW21D ARE EXISTING WELLS, OTHER WELLS ARE PROPOSED.
2. GROUND SURFACE ESTIMATED FROM NEARBY WELLS.
3. WATER-LEVEL ELEVATION ESTIMATED FROM AUGUST, 2000 WATER-TABLE MAP.
4. DEPTH TO BEDROCK ESTIMATED FROM BEDROCK ELEVATION MAP AND ESTIMATED GROUND SURFACE.

NA NOT APPLICABLE.

SAND PACK MATERIALS SCHEDULE

SAND PACK
OGLEBAY NORTON # 16-30

U.S. SIEVE NO.	PERCENT PASSING BY WEIGHT
12	100
16	99.6
20	53.2
30	6.4
40	1.1

COLORADO REGISTERED PROFESSIONAL ENGINEER
JON K. WILKEN
30995
Jon K Wilken
7/12/01

NO.	DATE	REVISIONS	BY	CHK
1	07/01	FINAL	JKW	KSC

DRAWN: SLJ
ENGINEER: JKW
CHECKED: KSC
DATE: 7/12/01
PROJECT NO: 42708.24.1
SCALE: NTS
APPROVED: KLD
DATE: 7/12/01

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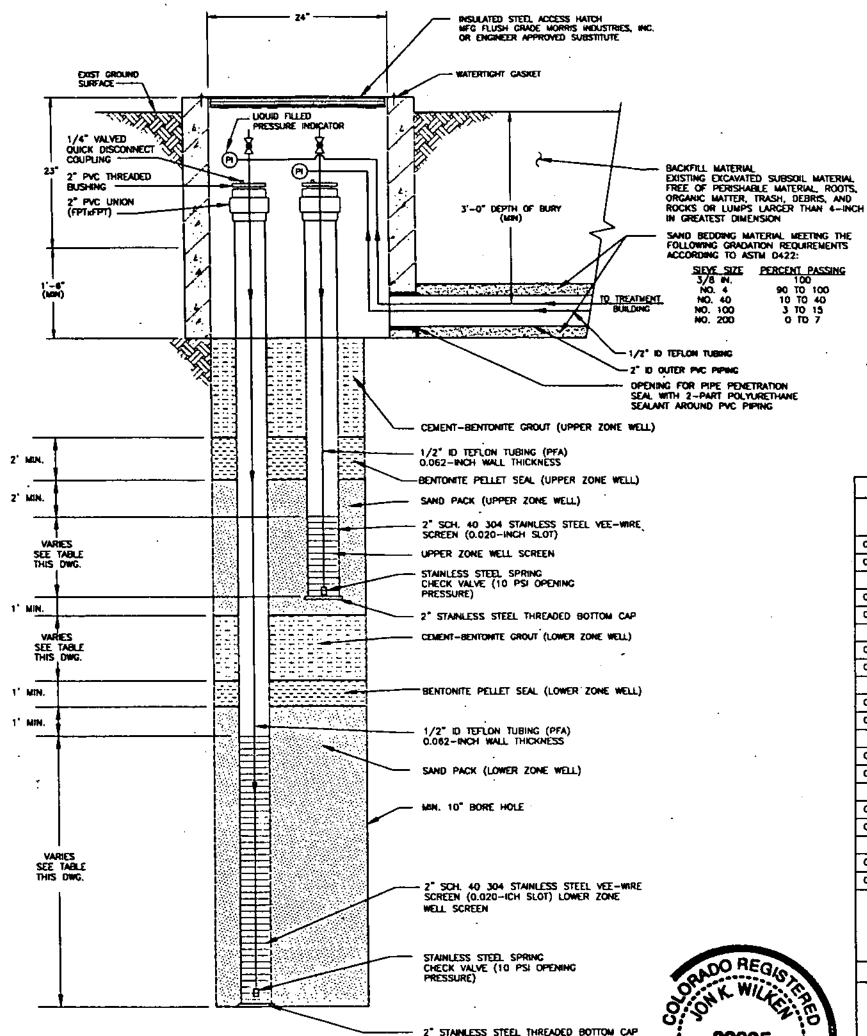
CDOT REGION 6 HEADQUARTERS
BIODEGRADATION
INJECTION SYSTEM
DENVER, COLORADO

CIVIL

SINGLE COMPLETION
INJECTION/MONITORING WELLS
AND VAULTS

DRAWING NO: C-3
7 / 23

40000/42708/CAD/REGION6/42708040 7/9/01 CWC



INJECTION WELL AND VAULT PIPING SECTION (8 / C-2)

NTS

DUAL COMPLETION INJECTION/MONITORING WELL AND CONSTRUCTION TABLE

WELL NUMBER	NORTHING	EASTING	GROUND SURFACE ELEVATION [1]	APPROX. WATER ELEVATION [2] (FEET AMSL)	APPROX. DEPTH TO BEDROCK [3] (FEET BGS)	APPROX. DEPTH OF SURFACE CASTING	FEET OF CEMENT-BENTONITE GROUT	FEET OF SAND PACK	FEET OF BENTONITE PELLET SEAL	SCREEN INTERVAL (FEET BGS)	SCREEN LENGTH (IN FEET)	SAND PACK MATERIAL	SCREEN SLOT SIZE (INCHES)	TOTAL DEPTH (FEET BGS)
C-IW4A	1,673,507	3,163,082	5454.5	5435.3	14	NA	15	12	3	20-30	10	16-30	0.02	30
C-IW4B				5429.0	14	NA	2	21	2	35-55	20	16-30	0.02	55
C-IW6A	1,673,508	3,163,095	5454.5	5432.5	16	NA	19	7	4	25-30	5	16-30	0.02	30
C-IW6B				5429.0	16	NA	4	21	3	38-58	20	16-30	0.02	58
C-IW7A	1,673,483	3,163,094	5454.5	5432.5	15	NA	14	12	4	20-30	10	16-30	0.02	30
C-IW7B				5429.0	15	NA	3	21	2	36-56	20	16-30	0.02	56
C-IW10A	1,673,481	3,163,050	5454.5	5434.5	14	NA	14	12	4	20-30	10	16-30	0.02	30
C-MW34B				5429.8	14	NA	3	21	2	36-56	20	16-30	0.02	56
C-MW31A	1,673,468	3,163,028	5454.5	5432.5	15	NA	19	7	4	25-30	5	16-30	0.02	30
C-MW31B				5429.0	15	NA	4	21	3	38-58	20	16-30	0.02	58
C-MW32A	1,673,501	3,163,112	5455.0	5436.2	14	NA	14	12	4	20-30	10	16-30	0.02	30
C-IW3B				5438.0	14	NA	3	21	2	36-56	20	16-30	0.02	56
C-MW35A	1,673,525	3,163,109	5454.5	5432.5	15	NA	19	7	4	25-30	5	16-30	0.02	30
C-MW35B				5429.0	15	NA	4	21	3	38-58	20	16-30	0.02	58

NOTES:

1. EACH OF THE DUEL COMPLETION WELLS ARE PROPOSED.
2. GROUND SURFACE ESTIMATED FROM NEARBY WELLS.
3. WATER-LEVEL ELEVATION ESTIMATED FROM AUGUST, 2000 WATER-TABLE MAP.
4. DEPTH TO BEDROCK ESTIMATED FROM BEDROCK ELEVATION MAP AND ESTIMATED GROUND SURFACE.

NA NOT APPLICABLE.

SAND PACK MATERIALS SCHEDULE

SAND PACK
OOGLEBAY NORTON # 16-30

U.S. SIEVE NO.	PERCENT PASSING BY WEIGHT
12	100
16	99.8
20	53.2
30	6.4
40	1.1

COLORADO REGISTERED PROFESSIONAL ENGINEER
JON K. WILKEN
30995
Jon K Wilken
7/12/01

NO.	DATE	REVISIONS	BY	CHK
1	07/01	FINAL	JKW	KSC

DRAWN: CWC
ENGINEER: JKW
CHECKED: KSC
DATE: 7/12/01
PROJECT NO: 42708.24.1
SCALE: NTS
APPROVED: KPQ
DATE: 7/12/01

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CDOT REGION 6 HEADQUARTERS
BIODEGRADATION
INJECTION SYSTEM
DENVER, COLORADO

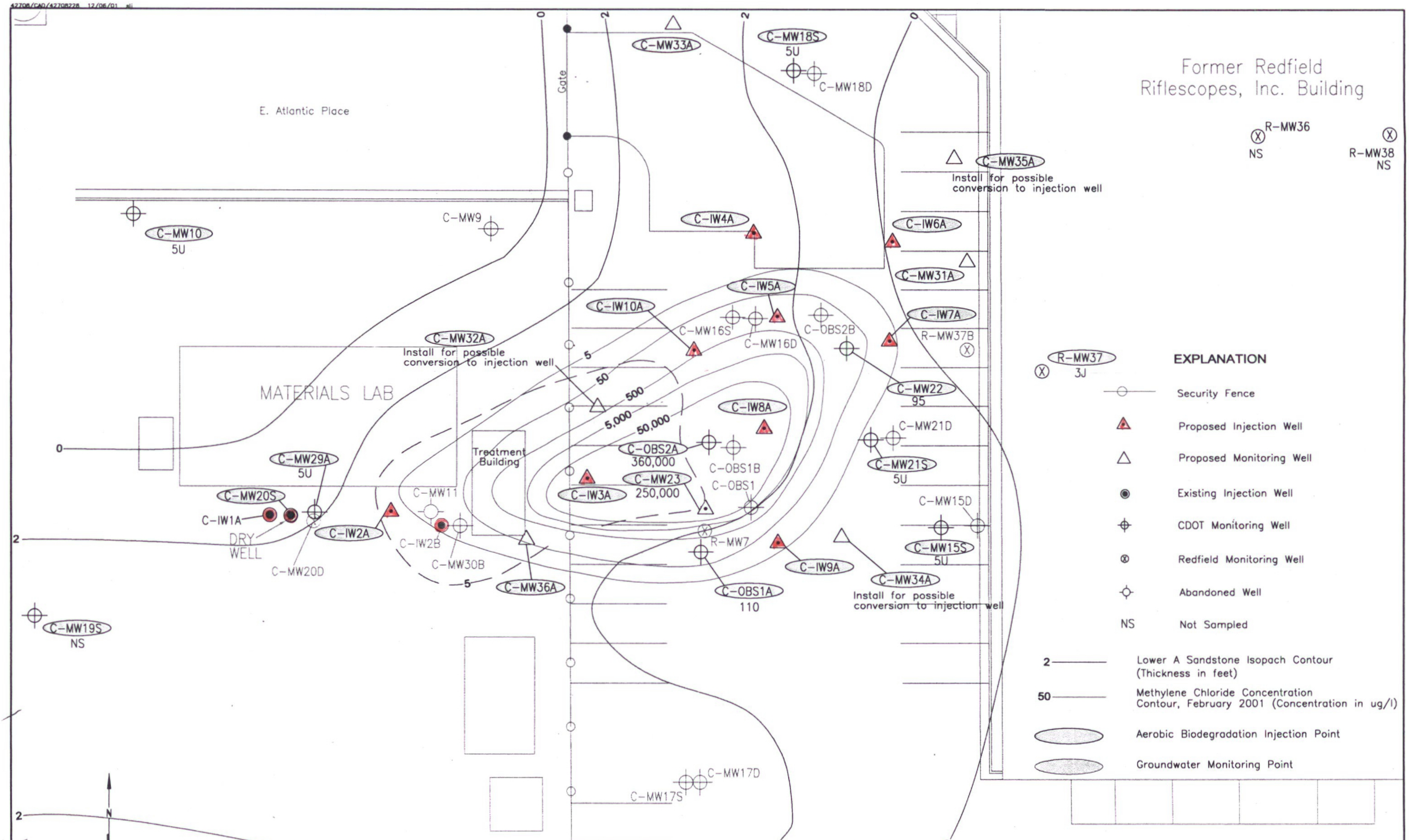
CIVIL

DUAL COMPLETION
INJECTION/MONITORING WELLS

DRAWING NO: C-4

8 / 23

0000/42708/CAD/REGION6/42708042 7/9/01 CWC



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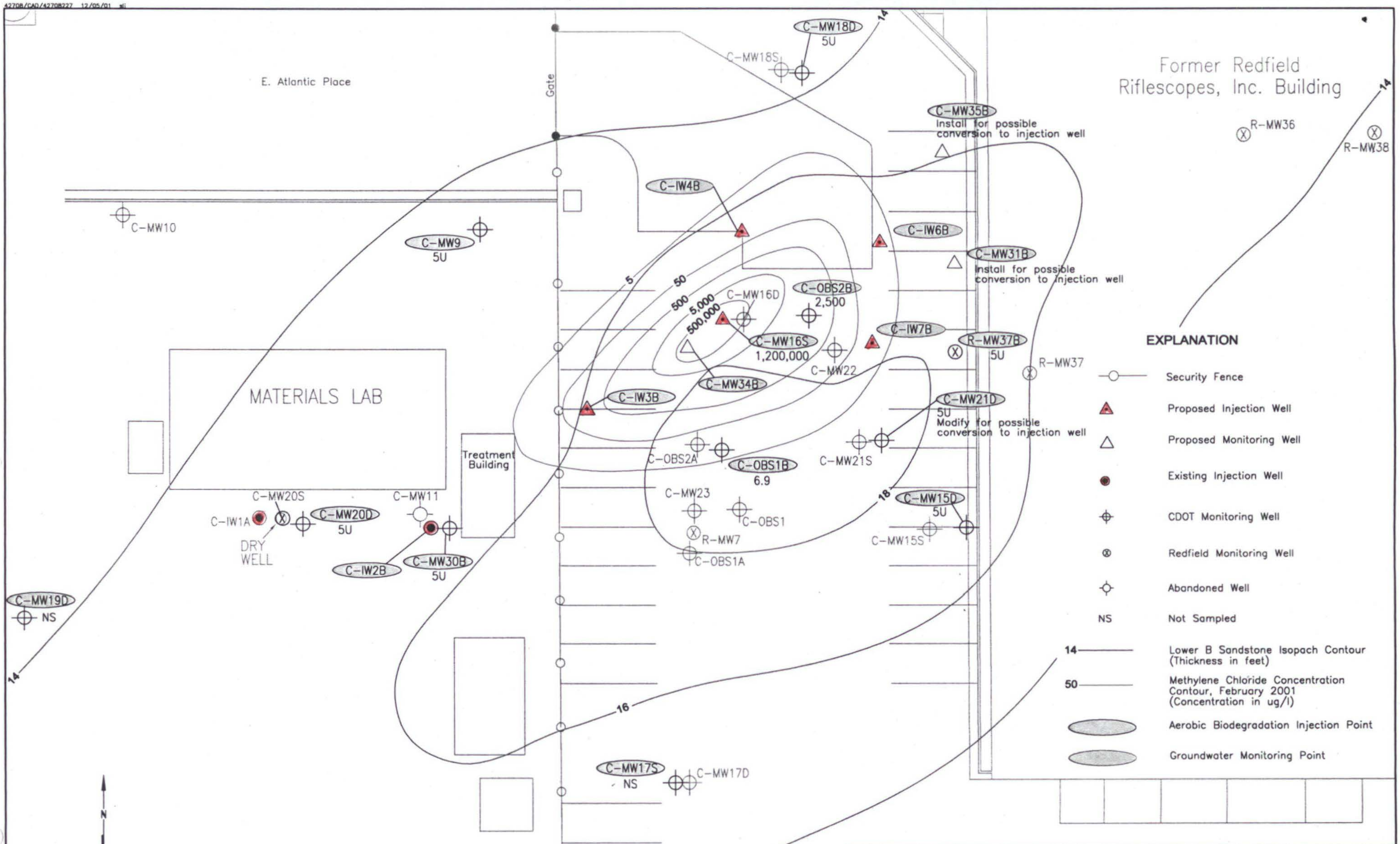
Proposed Injection Well and Monitoring Well Network For In Situ Biodegradation in the Upper Zone
CDOT Region 6 Headquarters Site
Denver, Colorado

FIGURE 3.1

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
SLJ	42708		11/00	



Harding ESE
A MACTEC COMPANY

Proposed Injection Well and Monitoring Well Network For In Situ Biodegradation in the Lower Zone
CDOT Region 6 Headquarters Site
Denver, Colorado

FIGURE 3.2

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
SLJ	42708		11/00	

Table A3: Schedule for Groundwater Quality Sampling

		Month of Operation			
Sample Frequency	Baseline Once	1 Once	3-24 Quarterly	25-Shutdown* Semiannually	Shutdown-24# Quarterly
Upper Zone Groundwater Monitoring Network					
Injection Wells					
C-IW1A	F	-	-	-	V
C-IW2A	F	-	-	-	V
C-IW3A	F	-	-	-	V
C-IW4A	F	-	-	-	V
C-IW5A	F	-	-	-	V
C-IW6A	F	-	-	-	V
C-IW7A	F	-	-	-	V
C-IW8A	F	-	-	-	V
C-IW9A	F	-	-	-	V
C-IW10A	F	-	-	-	V
C-MW20S	F	-	-	-	V
C-MW23	F	-	-	-	V
Monitoring Wells					
C-MW10	F	-	F	F	V
C-MW15S	F	V	F	F	V
C-MW18S	F	-	F	F	V
C-MW19S	F	-	F	F	V
C-MW21S	F	V	F	F	V
C-MW22	F	V	F	F	V
C-MW29A	F	V	F	F	V
C-MW31A	F	V	F	F	V
C-MW32A	F	V	F	F	V
C-MW33A	F	-	F	F	V
C-MW34A	F	V	F	F	V
C-MW35A	F	V	F	F	V
C-MW36A	F	V	F	F	V
C-OBS1A	F	V	F	F	V
C-OBS2A	F	V	F	F	V
R-MW37	F	V	F	F	V
Lower Zone Groundwater Monitoring Network					
Injection Wells					
C-IW2B	F	-	-	-	V
C-IW3B	F	-	-	-	V
C-IW4B	F	-	-	-	V
C-IW6B	F	-	-	-	V
C-IW7B	F	-	-	-	V
C-MW16S	F	-	-	-	V

Table A3: Schedule for Groundwater Quality Sampling (continued)

		Month of Operation			
Sample Frequency	Baseline Once	1 Once	3-24 Quarterly	28-Shutdown* Semiannually	Shutdown-24# Quarterly
Monitoring Wells					
C-MW9	F	-	F	F	V
C-MW15D	F	-	F	F	V
C-MW17S	F	-	F	F	V
C-MW18D	F	-	F	F	V
C-MW19D	F	-	F	F	V
C-MW20D	F	V	F	F	V
C-MW21D	F	V	F	F	V
C-MW30B	F	V	F	F	V
C-MW31B	F	V	F	F	V
C-MW34B	F	V	F	F	V
C-MW35B	F	V	F	F	V
C-OBS1B	F	V	F	F	V
C-OBS2B	F	V	F	F	V
R-MW37B	F	V	F	F	V

Field parameters listed in Section A2.4.2 will be measured every two weeks for the first six weeks of operation, and then concurrent with scheduled groundwater sampling events thereafter.

Samples for the analysis of bromide will be collected every two weeks for the first eight weeks of operation. These samples will be collected at the same monitoring wells designated for sampling at the one month sampling event. In the event that bromide is not detected at the perimeter monitoring wells within the first eight weeks of operation, sampling for bromide will continue at one-month intervals, as necessary, through the first six months of system operation. Any future injection of bromide and subsequent monitoring will be subject to discussion with the Colorado Department of Public Health and Environment pending the results of this study.

F Full suite of analytes listed in Table A4
V VOCs and Light Hydrocarbons

* After the first two years of system operation, sampling frequency will be re-evaluated on the basis of analytical results presented in the annual report.
\# Samples will be collected quarterly for two years following system shutdown.